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Propagation of Woody Plants

By Stuart Dunn and Russell Eggert

THIS report is on a continuation of the work with sugar maple cuttings summarized previously (2), and on results with cuttings of apple and hazel-filbert hybrids. Many of the same techniques of gathering and handling the cuttings were again used. Since high moisture of the air around the cuttings by constant mist was shown to be important, this was further emphasized with some variations. Use of sawdust as a rooting medium had shown some promise, so further comparison of it with other materials was made. Since no survival of the rooted cuttings had been obtained after exposure to their first winter, considerable attention was given to this phase of the investigation.

A description of variations from the methods previously developed will be given in the discussion of the results with different treatments. For some of the treatments, the results over a 5-year period. 1954-59 inclusive, are summarized. For others, shorter periods are involved.

Effect of Kind of Propagating Bed

There were in all 6 different kinds of propagating beds tested.

(A) *Greenhouse Ground Bed with Whitewash Shade.* This was a large bed 16′ by 4′ by 2′ deep. Shade was provided by a fairly thick coating of whitewash on the greenhouse roof. For tests in two of the seasons, half of this bed was filled with sand. the other half with sawdust. For the rest of the time it was filled entirely with sawdust, except in the last year (1958) when a part of it was filled with perlite. The maple cuttings used to fill this and all other beds were gathered and placed in the beds early in July as described before (2). Their foliage was kept moist by constant mist, using oil-burner type nozzles (No. 4.00-60PLP) delivering 4 gallons of water per hour. These gave a very fine mist which was ideal. See Figure 1 for type of bed and distribution of mist. Good drainage of the bed was provided by two lines of tile running its complete length.

(B) *Outdoor Bench with Cloth Shade.* This was made with boards on bottom and sides, supported above the ground at waist level by 2″ x 4″ legs. It was made in three sections, each 6′ x 3′ and about 8″ deep. A wooden frame supported a brown nylon netting for shade during two seasons. Later, woven Saran shading cloth was used and this was more satisfactory. This bench was supplied with the same rooting media and type of mist as the greenhouse bed.

(C) *Small Outdoor Bed with Cloth Shade.* This was built of wood sides, directly on the ground. 6′ x 3′, with a layer of coarse gravel beneath, and with a canopy of burlap for shade. This provided a low-cost propagating bed. It also had constant mist.

Figure 1. Maple cuttings in ground bed with constant mist. This photograph shows the type of mist produced.

(D) *Plastic Covered Bench in Greenhouse with Fan Aeration.* This was based on a report by Sweet and Carlson (4) in which they found that apple and cherry cuttings could be rooted in a bed supplied with intermittent mist in an air chamber covered with a canopy of plastic sheeting. Through this a stream of air was drawn by an exhaust fan. A bed very similar to this was set up, size 6′ x 3′, and filled with sawdust. It was supplied with intermittent mist, operated by the drying action of an "artificial leaf" attached to a solenoid valve.

(E) *Greenhouse Bench Aerated from Below.* This was a wooden bench, 3′ x 6′, fitted with an air-tight metal bottom. Above this was a one-inch air gap. Above the air gap the medium rested on hardware cloth supported by wood slats spaced one inch apart. This permitted air to pass continuously through the sawdust in which the cuttings were inserted. This bed also received intermittent mist.

(F) *Greenhouse Bench with Tight Plastic Cover.* Several descriptions of this type of bed have been published in nursery trade journals and elsewhere. Typical of these is the one described by Coggeshall (1). Essentially, this consists of a propagating bed enclosed above by a moisture-tight covering of plastic sheeting supported usually by wire netting at some distance above the cuttings. Theoretically this is supposed to need little or no additional water, the vapor from the water-soaked medium keeping the air above the cuttings saturated. A bed similar to this was set up at one end of a greenhouse bench, and, to aid in cooling the interior, several thicknesses of cheesecloth on top of the plastic cover were sprinkled with water at intervals. Water was added to the cuttings and medium fairly often. The temperature rose to a very high point (95-105°F.) in this "sweat-box" type of bed on warm summer days. This was tested for only one season.

Table 1. Effect of Kind of Bed and Moisture Treatment on Rooting of Sugar Maple Cuttings

Moisture Supply	Kind of Bed	Total No. of Cuttings	Number Rooted	Number Callused	Percent Rooted	No. of Seasons Tested
Constant mist	Greenhouse ground bed — whitewash shade	3660	1068	1112	29	5
	Outdoor bench — cloth shade	2988	814	920	27	4
	Small outdoor ground bed — cloth shade	450	166	23	37	2
Intermittent mist	Plastic covered bench — greenhouse — fan aerated	570	163	160	28	2
	Greenhouse bench aerated from below	225	23	79	10	1
Moisture sealed in — watered as needed	Greenhouse bench with tight plastic cover	318	74	145	23	2

The results of tests in all beds are summarized in Table 1. Based on the percentage of rooting, the small outdoor ground bed with cloth shade (C), gave the best response (37 percent). Although the total number of cuttings tested in it was relatively small, this type of bed does have definite possibilities. The chief recommendations for it are simplicity of construction and ease of operation, plus low cost. Bed (A), greenhouse ground bed with whitewash shade and constant mist, proved to be next best in rooting response (29 percent), although the margin was slight between the results with it and those with type (B), outdoor bench with cloth shade and constant mist (27 percent), and those with bed (D), the plastic covered bench with fan aeration and intermittent mist (28 percent). However, the extra expense, care, and trouble encountered with intermittent mist devices, whether with or without special covers or aerating fans, would be distinctly against the use of this method. As to type (F), the bench with moisture-tight cover, the somewhat lower rooting response (23 percent), together with the extra care and attention it requires, do not recommend this type of bed. Lowest amount of rooting of all beds was obtained with bed (E), the one with forced aeration from below, (10 percent). On the basis of these results this method is not worth further consideration. From all the results the general conclusion may be drawn that the use of beds or benches either in the greenhouse or outdoors, with constant mist and some shade, will provide good rooting conditions for sugar maple cuttings.

Effects of Medium on Rooting

As mentioned in the publication cited above (2), earlier results had shown sawdust to have promise as a rooting medium in contrast to sand. Prior to this published report, preliminary experiments had shown mixtures of sand and peat in various proportions, and waste bark to be inferior to sand alone. In order to definitely establish the value of sawdust in this respect, for two seasons a comparison of sawdust was made with sand. Separate portions of two different beds were filled with each material. Both media were tested with nearly equal numbers of cuttings from each clonal source. Those cuttings were given similar treatment. In another season a similar comparison was made of perlite with sawdust.

The results of these tests are summarized in Table 2. These show that sawdust is superior to either of these other two materials as a rooting medium under the conditions of these experiments. It may be mentioned that sawdust has other advantages. One is that it is much lighter in weight than sand, and therefore easier to handle and store. It is usually cheaper than other media and easily obtainable.

Table 2. Effect of Medium on Rooting of Sugar Maple Cuttings

Year	Medium	Number Tested	Number Rooted	Number Callused	Percent Rooted
	Sand	664	143	255	21
1954	Sawdust	648	182	238	28
	Sand	838	115	114	12
1955	Sawdust	838	200	194	25
	Sand	1502	258	369	17
Totals	Sawdust	1486	382	432	26
	Sawdust	168	54	44	32
1958	Perlite	168	19	35	11

Effect of Growth Regulators

The data reported previously (2) had shown some slight advantage for growth regulator treatments, the best one being indolbutyric acid at 0.1 percent strength (quick-dip method). For further information, tests were continued with a few of these substances for two more seasons. Also, on recommendation by Dr. P. W. Zimmerman of the Boyce Thompson Institute (personal communication), the dry powder manufactured by Merck and Co., known as Hormodin No. 3, was tested for two additional seasons. The results are summarized in Table 3. Here again, some slight superiority is shown for one of the growth regulator treatments over the controls, but probably not enough to warrant the extra labor and expense of treatment with these materials.

Table 3. Effect of Growth Regulators on Rooting of Sugar Maple Cuttings

Part A. Solution Treatments — Quick-dip Method

Treatment		Number Tested	Number Rooted	Number Callused	Percent Rooted
Control		1002	274	232	27
Indolbutyric acid	0.1 %	348	122	91	35
	0.02%	562	113	80	24
	0.01%	308	82	133	26
Indolacetic acid	0.1 %	323	86	92	26
	0.01%	292	68	102	23
p-chlorophen-oxyacetic acid	0.5 %	562	74	71	14
Naphthalene-acetic acid	0.02%	261	49	42	20
For growth regulators, totals and average % rooting exclusive of that for p-chlorophenoxyacetic acid		2094	520	540	25
Part B. Dry Powder Treatment					
Control		828	247	380	30
Hormodin No. 3		828	289	183	35

Clonal Differences

Some variations in rooting of sugar maple cuttings from different clones were observed previously (2). For each season of the work reported here. records were kept of the rooting response of the cuttings from different trees. The records are summarized in Table 4. Trees numbered 3, 4, 5. and 6 were part of a row of old trees along a roadway at the Horticultural Farm, University of New Hampshire. Records kept of trees 3 and 5 have shown their sap to be exceptionally high in sugar content. Tree 3 is exceptionally vigorous with a pronounced "bushy" type of top growth. In

Table 4. A Summary of Clonal Differences in Rooting of Sugar Maple Cuttings over a 5-year Period, 1954-1958

Tree No.	Number of Seasons	Number Tested	Number Rooted	Number Callused	Percent Rooted
3	5	2074	906	416	43
4	4	1345	329	411	24
5	5	2208	194	1093	9
6	4	645	217	93	33
8	4	1198	433	302	36
9	4	635	235	97	37
Totals		8105	2314	2412	28 (Ave.)

contrast, tree 5 is less vigorous and has fewer scaffold limbs. Whether this type of growth has anything to do with the high percentage of rooting by cuttings from tree 3 is unknown. Tree 8 is actually a closely-growing clump of three main trunks, medium in age (about 20 years) and very vigorous. This clump grows near a loading dock. Tree 9 in Table 4 represents cuttings taken from several young trees (perhaps 10 to 15 years old) at the edge of the clearing at this general location. It is evident that the clonal source of cuttings does make a great difference in rooting response. Of especial interest is the contrast between rooting of those from Tree 5 (9 percent) and Tree 3 (43 percent). Both are old trees and high in sugar yield, but differ in vigor and growth habit.

It should be mentioned at this point that it is often difficult to collect a large uniform group of cuttings from any one tree or clonal source. Frequently the greenwood shoots are too short to make good cuttings. On the other hand, cuttings from water-sprouts that are too long and have grown too rapidly are prone to rot very readily. This must be taken into account in making comparisons of effects of various factors, such as growth regulators, media, etc., within a group of clonal material.

In connection with the matter of clonal differences, it may be mentioned that Muckadell (3) has presented some evidence that younger portions of a woody plant are more active in many ways. It seemed desirable to determine if cuttings taken from the topmost part of an old maple tree would root better than those taken lower down. A small number of cuttings were taken in 1957 from near the top of Tree 3 (a very tall tree), and records kept of their rooting as compared to those taken in the usual way in an area extending from the base of the foliage up to a height of about 16 or 20 feet. From a total of 111 cuttings taken from the top there were 43 rooted or a percentage of 39. Of the total number of 485 cuttings taken lower on the tree, 279 or 57 percent rooted. On the basis of these relatively few cuttings there is no advantage shown for taking them from the top part of the tree. However, it is probably unsafe to regard this as very conclusive evidence, since the sample was not large, and was taken for only one season.

The Survival of Rooted Cuttings

From the evidence presented here, and in the published report (2), the problem of rooting fairly large numbers of sugar maple cuttings can be regarded as being virtually solved. However, the additional problem of securing their survival through one or more winters following their rooting is only partially resolved.

It may be noted at this point that usually only the most vigorously rooted cuttings were chosen for potting and keeping for survival tests. This was true except in instances of clones where rooting was poor and scanty, as in the cuttings of Tree 5. Examples of vigorous rooting and weak rooting may be seen in Figure 2. Single, "club-shaped" roots of the type on the bottom side of the photograph were very weak and easily broken. Rooted cuttings of this type were usually discarded.

Previous to the year 1955 all of the rooted maple cuttings had been potted in early fall and later when fall rains started were set out in a specially prepared nursery bed at the Horticultural Farm. These were mulched rather deeply with sawdust after the ground was partly frozen, and were

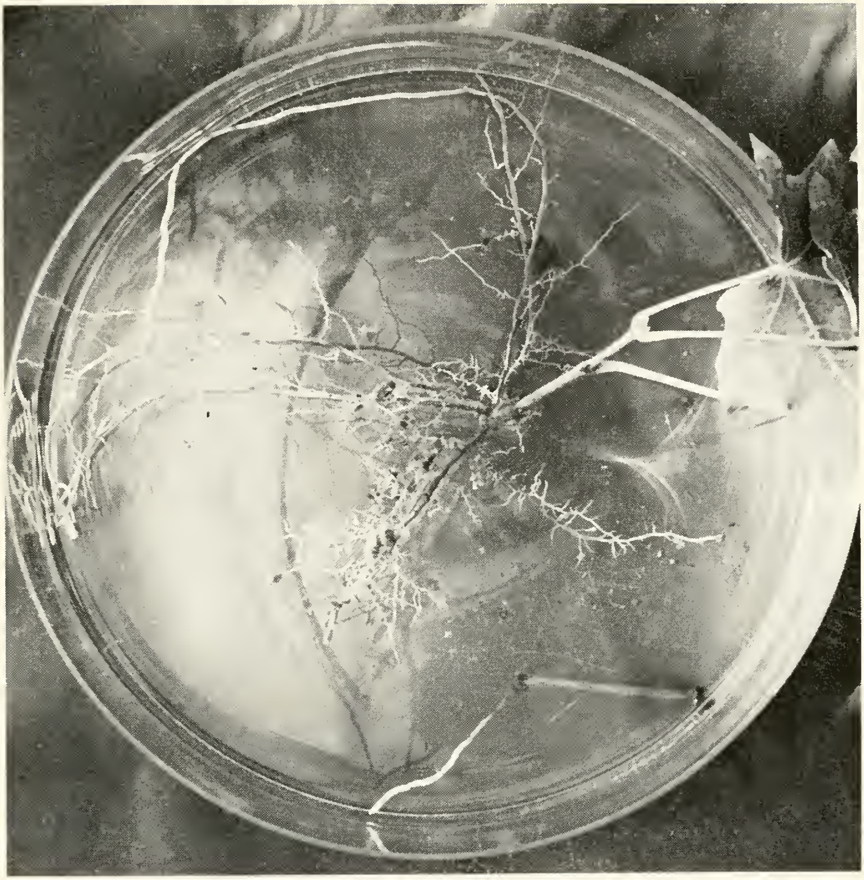

Figure 2. Types of rooting in sugar maple cuttings. Those at the top are vigorous; those at the bottom, weak.

further protected by a wooden inverted V-shaped shelter of lath. None of the cuttings thus treated survived the winter. At the close of the rooting season of 1955 half of the rooted cuttings were given this same treatment and the other half were potted and were packed in boxes with sawdust up to the tops of the pots. They were taken to the Horticultural Farm and left on the ground beside the barn to harden. At the onset of very cold weather, just before the final freeze-up, they were placed in a sheltered room beneath the barn, where they were covered with a thick layer of sawdust on all sides and top, held in place by heavy building paper.

The following May the boxes of rooted plants were moved into daylight outside the barn and evidence of survival awaited by renewal of vegetative growth. Of 200 plants thus treated, 111 or 57 percent were alive on May 20, 1956. By September 1, 1956, about 45 were alive and growing in the field. Of those planted directly in the nursery the previous fall, none survived. Based on this kind of evidence, for all subsequent seasons the rooted cuttings were given the same kind of sawdust packed treatment that had resulted in some survival.

The same technique did not result in equal success in securing survival in later seasons, however. Also there has been further mortality in those plants surviving the first winter in the field. Of those kept over winter from the seasons of 1957 and 1958, none have survived to date. The reasons for this are somewhat obscure, but it seems evident that the temperature dropped too low in the storage area at some time during these two winters. At present the survival score stands as given in Table 5. These are all vigorous and growing well. This is not a very impressive total from the thousands of cuttings that have been rooted, but it shows that it can be done!

Table 5. Survival of Cuttings — Sugar Maple in Nursery Row as of June 5, 1959

Tree No.	From 1954 Rooting and 1955 Planting	From 1955 Rooting and 1956 Planting	From 1956 Rooting and 1957 Planting
No. 3	1	3	3
No. 4	4		
No. 5	0		
Y.T. (No. 9)	11		
L.D. (No. 8)	14		
Totals	30	3	3
	Total of all surviving 36		

At this point, a few comments and suggestions may be in order, to serve as a guide to those who may wish to propagate woody plants by these methods or to improve upon them. One chief problem is the pot-bound condition of the potted cuttings at the time of placing them in the nursery row. It takes a long time for side roots to become established and such plants are not anchored as well as they should be. Another is that they seem to require a winter temperature slightly above 32°F., but which does not fall below that point. Perhaps the solution to both problems would be to transplant the rooted cuttings directly to a cutting bed which will later be held in refrigeration at 32° to 34°F. until the end of the winter period.

Experiments on Cuttings of Hazel-Filbert Hybrids and Young Apple Stock

To explore the potential applications of the methods found effective in rooting maple to other woody species, tests were made on a limited number of cuttings from apple stock and from hybrids of hazel-filbert. These were taken from young trees at the Horticultural Farm. Experiments were made on the effects of growth regulators with both kinds of cuttings and on the effect of taking cuttings from different positions on the plant (lateral vs terminal) with *Malus robusta* No. 5 in 1955 and 1956. The cuttings were all tested in the sawdust-filled bench (outdoors) with constant mist. The results of these experiments are summarized in Tables 6 and 7. It is shown there that cuttings of *M. robusta* responded with a higher percentage of

Table 6. Effect of Growth Regulators on Rooting of Cuttings of *Malus robusta* No. 5

Part A. Solution Treatments — Quick-dip Method

Treatment		Number Tested	Number Rooted	Number Callused	Percent Rooted
Control		156	68	61	43
Indolbutyric acid	0.1 %	32	19	7	59
	0.02%	72	25	15	35
	0.01%	64	31	27	48
Indolacetic acid	0.1 %	32	16	13	50
	0.01%	32	17	14	53
Part B. Dry Powder Treatment					
Control		42	22	16	52
Hormodin No. 3		70	35	28	50

Table 7. Effect of Growth Regulators on Rooting of Cuttings of Hazel-Filbert Hybrids

Treatment		Number Tested	Number Rooted	Number Callused	Percent Rooted
Control		106	13	42	12
Indolbutyric acid	0.1 %	16	3	4	19
	0.02%	54	11	17	20
	0.01%	32	5	15	15
Indolacetic acid	0.1 %	16	2	9	12
	0.01%	32	3	11	9
p-chlorophenoxyacetic acid	0.5 %	54	0	3	0
Naphthalene acetic acid	0.02%	36	1	16	0.3

rooting than those of hazel-filbert. Some advantage is shown for growth regulator treatments, except for that in dry powder form (Hormodin No. 3). It is evident that these methods can be used successfully on other woody plants besides sugar maple.

That there is a definite advantage in taking cuttings from the terminal position over those in the lateral position with *M. robusta* No. 5 is shown in the summary for two years results in Table 8. The limited tests on two clones of apple in 1958 (Table 9) indicate that rooting by *M. robusta* No. 5 was better than that of N. H. 55 stock.

Table 8. Effect of Position on Plant (from which Cuttings were taken) on Rooting of *Malus robusta* No. 5

Year	Position	Number Tested	Number Rooted	Percent Rooted
1954	Terminal	96	78	81
1955	Terminal	90	56	62
	Totals	186	134	72 (Ave.)
1954	Lateral	112	31	27
1955	Lateral	90	11	12
	Totals	202	42	20 (Ave.)

Table 9. Clonal Differences in Rooting of Apple Cuttings, 1958

Clone	Number Tested	Number Rooted	Number Callused	Percent Rooted
N. H. 55	42	13	29	31
Malus robusta 5	70	44	15	63

Summary

1. Propagating beds or benches filled with sawdust and provided with constant mist and moderate shade were more satisfactory for rooting cuttings of woody plants than beds with other media or with special aerating devices or with intermittent mist, under the conditions of this experiment.

2. The use of growth regulators may produce somewhat higher percentages of rooting in such cuttings, but it is doubtful if the advantage is worth the extra work and expense of their use.

3. Clonal variations in rooting response are very pronounced. The factors that influence these variations are largely unknown.

4. The problem of securing rooting of cuttings of the species of woody plants used in this experiment may be regarded as solved. It can be done with a fair degree of success, with methods described here. The problem of securing survival of the rooted cuttings of sugar maple during succeeding winters after their rooting, remains a very large one. The results presented here show that it can be done, with proper care. However, the percentage of survival is yet very small and it is toward the goal of increasing that percentage that future work should be directed.

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